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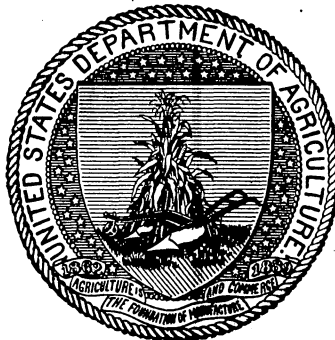
FARMERS' BULLETIN 352.

THE NEVADA MOUSE PLAGUE OF 1907-8.

BY

STANLEY E. PIPER,

Assistant, Biological Survey.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BIOLOGICAL SURVEY,

Washington, D. C., January 12, 1909.

SIR: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a report on the Nevada Mouse Plague of 1907-8, by S. E. Piper, an assistant in the Biological Survey.

The report is important from three points of view: (1) It is the first account we have ever had of a fully developed mouse plague in America; (2) it shows that such plagues may be successfully combated; and (3) it emphasizes the necessity for protecting our native hawks and owls and the smaller predatory mammals in order to prevent the recurrence of such plagues in future.

Respectfully,

C. HART MERRIAM,
Chief, Biological Survey.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE NEVADA MOUSE PLAGUE OF 1907-8.

INTRODUCTION.

This bulletin gives an account of the recent mouse plague in Humboldt Valley, Nevada. Its object is to acquaint farmers with the dangers from field mice and to describe the best methods of destroying and controlling the animals. Though referring particularly to the Nevada outbreak, the recommendations apply to similar species in other parts of the United States.

THE MOUSE PLAGUE IN HUMBOLDT VALLEY.

HISTORY OF THE OUTBREAK.

Damage by field mice attracted the attention of the ranchmen in the lower part of Humboldt Valley early in the spring of 1906 and became severe during the following summer.^a In the fall and winter of 1906-7, damage had increased until fields here and there in the valley were seriously injured. Extensive ravages first occurred above and about Lovelocks. In May, 1907, fields on the Rodgers ranch, 5 miles below Lovelocks, were invaded from the lands farther up the valley, the progress of the mice being plainly marked, as the fields above the Rodgers ranch suffered first. The movement of this great body of mice, it should be noted, was a gradual, scattering progression, first by a few and later by increasing numbers, until the greater part had moved to fresh fields. Numbers, however, finding conditions improved, remained as stragglers in the fields deserted by the main body.

By October, 1907, a large part of the cultivated lands in this district had been overrun by vast numbers of mice. The yield of hay had been reduced by one-third; potatoes and root crops were largely destroyed; many alfalfa fields were ruined by the mice eating the roots of the plants; and the complete destruction of this, the chief crop in the valley, was threatened.

The height of abundance was reached in November, when it was estimated that on many large ranches there were from 8,000 to 12,000

^a Reported by J. S. Cotton, Sept., 1906.

mice to each acre.^a The fields were riddled by their holes, which were scarcely a step apart, and over large areas averaged 150 to 175 to the square rod. Ditch embankments were honeycombed, and the scene was one of devastation. Serious losses in hay and root crops during the summer proved but a slight forerunner of the damage which began in the fall with the disappearance of green food. Burrowing down about the plants, and extending their underground runs from root to root, they either killed or seriously injured the alfalfa (fig. 1). By November they had destroyed so large a percentage of the plants



FIG. 1.—Alfalfa plant killed by field mice.

that many fields were plowed up as hopelessly ruined (see fig. 2). They attacked also the roots of trees, seriously injuring or quite destroying orchards. They killed most of the young shade trees planted along ditches, and so completely girdled large Lombardy and silver poplars (fig. 3) that in some cases they caused the death of even such hardy trees.

By January, 1908, in fields where the mice had existed by thousands the previous summer and fall, comparatively few, possibly 200 to 500 to each acre, remained. The border of the destroyed district was about 6 miles below

Lovelocks, and the mice were gradually moving further down the valley. In the area below this, mice were somewhat in excess of normal numbers and in several centers of abundance had seriously injured fields. Even where most abundant, along the lower border of the affected area, they did not exceed 1,500 to the acre. In the winter they attacked every available food supply. Small willows and even greasewood bushes about the borders of fields were stripped of all the bark within reach, and horse and cattle droppings were

^a Reported by Vernon Bailey, Nov., 1907.

gnawed to pieces for the food they contained. Alfalfa roots, however, were the food supply on which the mice were chiefly dependent.

EFFORTS OF RANCHMEN TO COMBAT THE PLAGUE.

In Nevada, the great majority of ranchmen knew neither what to expect from such great numbers of mice nor how to check them. It must be said, however, that no previous examples of successfully controlling such plagues exist; usually they have run their courses until brought to an end by natural agencies. Hence it is not surprising that in Humboldt Valley no concerted or systematic efforts to suppress the plague in its earlier stages were undertaken, but after the mice



FIG. 2.—Alfalfa field ruined by mice, showing general condition of fields in Humboldt Valley in January, 1907.

swarmed in thousands over the fields many attempts were made to destroy them by distributing wheat poisoned with phosphorus. These, however, were spasmodic and generally proved futile, as the fields experimented on were quickly reinvaded from adjoining lands. While a few fields favorably located were saved by early poisoning, the results of such unsystematic efforts amounted to practically nothing in overcoming or even materially checking the plague.

The preparation in general use by ranchmen consisted of wheat treated with a strong solution of yellow phosphorus in carbon bisulphid, a cheap and effective poison for field mice, but inflammable, explosive, and dangerous to birds. As a result of its extensive

employment in the valley, California quail, an introduced species, were decimated, and magpies, crows, meadow larks, and smaller seed-eating birds suffered extremely. On one occasion 67 horned larks were found dead on about 4 acres a few hours after the poisoned grain had been distributed. Fortunately hawks, owls, gulls, and ravens were not affected, but many skunks and domestic cats were killed as the result of eating mice dying or dead of phosphorus. Several accidents occurred in handling the solution, and cases of fatal poisoning of live stock were frequent.

Several attempts by ranchmen to induce contagious diseases among the mice by means of advertised bacterial preparations failed.

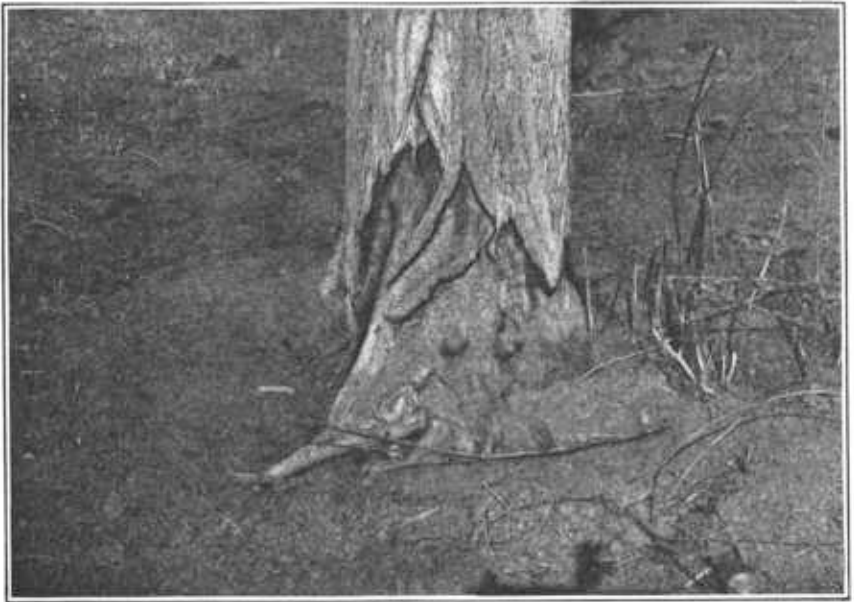


FIG. 3.—Lombardy poplar girdled and killed by field mice.

HOW THE OUTBREAK WAS FINALLY CONTROLLED.

Chiefly through the cooperation of Mr. George S. Webb, manager of the large Rodgers ranch, systematic experiments to destroy the pests, undertaken early in January by the Biological Survey, yielded results demonstrating that such mouse plagues can be controlled, and the greater part of the losses prevented. The experiments proved that mice could be effectively destroyed in winter by alfalfa hay poisoned with strychnia sulphate, and this preparation was generally recommended in the valley. On the Rodgers and Anker ranches a force of 7 to 15 men was employed to distribute the poison in the fields, with most satisfactory results, and without the dangers incident to the use of phosphorus and grain.

During this winter season, when the mice were not breeding, large numbers of predatory birds and mammals had steadily depleted their numbers. Mortality, believed to be due to disease, perhaps engendered by the straitened food supply and the severe winter weather, had been everywhere evident. Dead and dying mice attracted general notice, and in opening burrows where no poison had been distributed dead mice were frequently found in their nests.

By March 15, poisoning, supplemented by these natural agencies, had destroyed the mice on several thousands of acres where they were most abundant, and the plague was broken before the remaining alfalfa fields had been overrun. In scattered centers mice continued in destructive numbers until May, but without regaining to any considerable extent by reproduction, they steadily decreased. Later in the summer they had almost disappeared from the valley.

ESTIMATES OF DAMAGE.

The scourge of mice swept over about four-fifths of the cultivated area in the lower part of Humboldt Valley. Of about 20,000 acres in alfalfa, about 15,000 were so seriously injured as to require plowing and replanting. Over most of this area the alfalfa was replaced by grain crops for the season of 1908, at great expense and loss, since good alfalfa lands pay gross returns of from \$60 to \$70 per acre, while good grain crops return only \$35 or \$40 per acre.

The shortage of hay on the Rodgers ranch, where 2,200 acres were in alfalfa, was estimated at 2,000 tons. On Anker's ranch of 650 acres, it was estimated at 600 tons. Other ranches suffered in proportion, and the loss of hay in the valley amounted to not less than \$50,000. The following estimates, independently considered, indicate the severity of the depredations. W. C. Pitt, who farms 1,400 acres of alfalfa, estimates his complete loss at \$20 per acre, or \$28,000. John Font estimates his damage on 1,000 acres at \$20,000, and Mr. Anker considers his loss on 650 acres to be \$8,000. Mr. Webb, on the Rodgers ranch, figures the complete loss on 2,200 acres, part of which pays considerably short of the best returns, at \$30,500.

A careful consideration of the losses in hay, pasturage, root crops, and trees, the expense of restoring alfalfa fields to their former condition, and deducting the value of a grain crop for 1908 shows the average loss to be about \$20 per acre.^a On this basis the damage to the valley amounts to \$300,000. Allowing for the saving of a few fields by early poisoning, and for others not entirely destroyed, the loss may have been a little less than \$300,000.

Simultaneously with the plague in the lower part of Humboldt Valley mice appeared in enormous numbers farther up the Humboldt

^a Figured on the basis of 1,000 acres on Rodgers ranch.

River and its tributaries about Winnemucca, Battle Mountain, and in Paradise and Little Humboldt valleys. As the lands infested in those districts were chiefly great natural hay meadows of red top and wild clover, the damage was less severe. However, gardens and isolated alfalfa fields were seriously injured. Later, reports of mice in alarming abundance were received from King River, Quinn River, and Carson and Smith valleys, Nevada; from Weber River Valley, and from Sanpete and Utah counties, Utah; and from Honey Lake Valley, California. In none of these localities was the damage so extensive as in Humboldt Valley, though plagues of like severity were plainly threatened.

A PLAGUE THREATENED IN CARSON VALLEY.

Reports of severe damage by mice in Carson Valley, a hundred miles southwest of Lovelocks, in April, 1908, led to investigations which have an important bearing on the subject. Carson and Humboldt valleys are alike in having large areas in alfalfa bordered by desert lands on which field mice do not live. On a tract of about 2,500 acres near Minden, mice were found to be excessively abundant, and in some fields 10 to 25 per cent of the alfalfa plants had already been destroyed. Several smaller centers were similarly affected, while over the valley generally the mice were somewhat in excess of normal numbers. This was a condition similar to that presented in Humboldt Valley during the spring of 1907, and young of all sizes were abundant. Examination of many females, a large percentage of which were pregnant, showed an average of from 6 to 7 young, while in a number as many as 10 were found. Many females suckling young were found to be again pregnant. This was in marked contrast with the condition in Humboldt Valley, where, at this time, the mice were steadily decreasing without any general reproduction. The mortality among the mice so strongly in evidence during the winter and spring in Humboldt Valley was not found here. In fact, the pests were plainly increasing; while in Humboldt Valley they were steadily diminishing. Reproduction at the rate noted at Minden might and probably would have resulted in a plague by fall.

It can not be too strongly emphasized that at this stage of development mouse plagues can be checked, as was demonstrated by results actually obtained here. Although alfalfa was already well grown, furnishing the mice abundant food, by systematic poisoning they were so effectively reduced in the infested areas as not to be dangerous again during the season—in other words, a plague was averted.

PREVIOUS OUTBREAKS.

This is not the first time that field mice have inflicted serious damage in Humboldt Valley. Accounts by the older ranchmen indicate

that a similar scourge occurred from 1889 to 1892. The mice were very abundant during the period from 1899 to 1901, the outbreak approaching in severity the present one, though affecting less of the valley. Between these periods damage of more local nature was frequent. The same species was reported to be extremely abundant and very injurious to crops in Carson Valley in 1892,^a and several times since it has seriously menaced the valley.

ORIGIN AND PROGRESS OF SUCH PLAGUES.

A few observations on the development of this mouse plague are pertinent, since they bear directly upon the control or prevention of similar irruptions in the future. Always present in Humboldt Valley, these mice attract little attention when in small numbers. Usually they are not uniformly abundant in the district; in fact in many of the fields they may not be present at all. They live in scattered colonies in swampy places; along the borders of sloughs and irrigation ditches; in salt grass patches and in similar damp areas. When in normal numbers a little damage may be noticeable about the borders of fields or along ditches, where plants have been killed during winter and spring. Ordinarily the mice are very prolific, each pair producing 4 to 6 litters of about 6 young each during the long breeding season, which extends from March to November; and probably the young born early in the season breed before fall. Occasionally conditions favor excessive multiplication, and under such circumstances damage soon becomes evident, and in a single season may increase locally to the serious injury of fields. Extending from such centers during the next breeding season, and increasing not only by reproduction but by joining with other colonies, a vast army of mice is formed. Because of overcrowding and the limitation of food, such armies invade adjoining districts, and this progress becomes more rapid with the disappearance of green food in the fall. Through the combination of several such armies, entire districts are overrun.

Mice plagues usually develop within the affected districts. The essential point is this: It takes several seasons to produce a general plague of mice, and damage is noticeable for at least a season before a serious outbreak occurs. Though natural agencies may be depended upon to overcome such abnormal numbers finally; yet, unless active repressive measures are taken, enormous damage to crops will result. Control, easy at first, becomes more and more difficult as the mice increase in numbers, and, after a plague is well established, is very expensive.

^a W. W. Price, *Zoe*. Vol. 4, 1893-4.

THE SPECIES RESPONSIBLE FOR THE PLAGUE.

The mouse which produced the plague in Nevada, locally known as "black mouse" (fig. 4), proved to be the Carson field mouse (*Microtus montanus*), one of the numerous species of short-tailed field mice or meadow mice, a group which has caused widespread

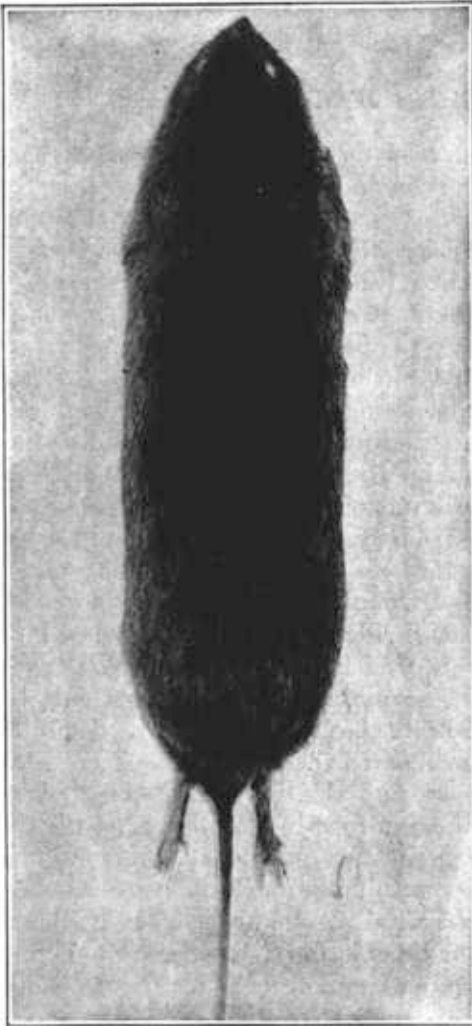


FIG. 4.—The Carson field mouse (*Microtus montanus*).

destruction in various parts of the world.^a This field mouse is rather widely distributed in the valleys of Utah, Nevada, northeastern California, and eastern Oregon. In nearly all parts of the United States short-tailed field mice are among the most abundant of mammals, and a number of species in widely separated localities have occasionally exhibited the same tendency to excessive increase, indicating that favoring conditions may produce mouse plagues wherever the mice exist. Even when in small numbers they destroy considerable clover and alfalfa and injure orchards, nurseries, and root crops.

This is the first recorded instance of an irruption of field mice in North America attaining the proportions of a plague. The experience indicates the probability of future and even more disastrous outbreaks. In the extensive reclaimed areas of the West the abundant food and luxurious cover furnished by alfalfa fields and the miles of irrigation

ditches, which afford these mice suitable homes along their banks, greatly favor their increase, while surrounding desert conditions limit the spread of mice beyond the cultivated areas.

^a For an account of the group see Bulletin 31, Biological Survey.

REPRESSIVE MEASURES.

POISONS.

Without doubt poisoning is the best method at present known of dealing with field mice on an extensive scale. Besides effectiveness, poisons should possess the additional advantage of small cost and the least possible danger to man, to domestic stock, and to valuable wild birds and animals. Comparative tests of a large number of poisons, including strychnine, phosphorus, lead acetate, mercuric chloride, arsenic and its compounds, proved strychnia sulphate by far the best and most practicable. Used in proper proportions it is no more costly than arsenic, lead acetate, or mercuric chloride. Moreover, it is much more readily eaten than are these poisons, which render some of the best baits unattractive to mice. Used on wheat it is considerably more expensive than phosphorus, but possesses many advantages; however, it may be used on mediums which make it the cheapest poison practicable.

Phosphorus.—Yellow phosphorus is exceedingly dangerous to handle and sometimes causes disastrous fires. Its solution in carbon bisulphid is highly explosive, while wheat grains poisoned with it are eaten readily by many birds. Thus the wheat poisoned with this solution, used by many Nevada ranchmen, was as dangerous a poison to prepare and to use as could well be devised. The preparation was in the form of a rapidly diffusing liquid, of which six ounces were sufficient to poison a sack of wheat.

Many ranchmen adopted the method of broadcasting the poisoned wheat over their fields, either by means of broadcast seeders or by hand. About 40 pounds of grain were required for each acre. Though many mice were killed, this method falls far short of yielding the best results. It is not much cheaper than other methods, as the proportion of poisoned grain wasted makes up for the lessened labor. Furthermore, its use is attended with the greatest possible danger to birds.

A much better method of distributing this poisoned grain is to drop about half a teaspoonful into each mouse burrow. Field mice limit their movements to their own systems of trails and burrows, and it is essential to place a fatal dose of poison within reach of each mouse. About 90 per cent of the mice were killed by this method, but in the worst-infested fields a man could cover only three or four acres a day, and the average cost, including labor, was from 80 to 90 cents per acre.

Strychnine.—Strychnine is commonly on the market in two forms. For the purpose of poisoning field mice, care should be taken to procure strychnia sulphate, as this is much more readily soluble in

water than ordinary strychnine crystals. Even in powdered form, the sulphate is required. It fluctuates considerably in price, but usually can be obtained wholesale at about 75 cents an ounce.

Poisons should always be prepared at a distance from the house, where stock and poultry are not endangered. To avoid danger to persons strychnine and the vessels in which it is used should, of course, be carefully handled and safely stored away when not in use. Ordinary 5-gallon oil cans, for which covers and wire handles have been provided, make excellent utensils. A firehole about 2 feet long and a foot wide, over which two iron rods are placed to support the cans, makes a fireplace where the solutions can be quickly prepared. Galvanized iron wash tubs are suitable for mixing the material if grain be used. For preparing poisoned alfalfa on the large scale usually necessary, a large metal receptacle which will permit the mixing of 30 pounds of hay at once is required. One or two oil cans marked into gallon measures, a sprinkling can, and several large strong spoons complete a handy outfit for preparing poisons.

BAITS FOR THE ADMINISTRATION OF POISON.

Tests with various baits or vehicles for poison show that three possess distinct advantages. These are alfalfa hay, green alfalfa, and crushed wheat.

Alfalfa hay.—Alfalfa hay was found to be the best vehicle or medium for carrying the poison in winter. It was used extensively in Humboldt Valley up to the time green food appeared in March. A single treatment of the fields destroyed from 85 to 95 per cent of the mice. Compared to the grain-phosphorus preparation it steadily gave as good or better results, and is about 30 per cent cheaper; furthermore, it is entirely without danger to birds.

Formula.

Chopped alfalfa hay	30 pounds.
Strychnia sulphate.....	1 ounce.
Water.....	5 or 6 gallons. ^a

The alfalfa hay should be fresh and green rather than bleached. Either chopped hay, including stems and leaves, or the fine material, chiefly leaves and blossoms from the bases of stacks, may be used. The chopped hay is preferable, since the stems retain the moisture longer. The hay should be chopped into about 2-inch lengths, an ordinary feed cutter being best for the purpose. The required quantity should be placed in a large metal receptacle, sprinkled with 3 gallons of fresh water, and well mixed with a pitchfork. Dissolve 1 ounce of strychnia sulphate in 2 or 3 gallons of water by heating

^a Or as much as the hay will absorb.

in a closed vessel. Sprinkle the solution over the dampened hay and mix well until the moisture is all taken up. The hay may now be sacked and is ready for use.

Only enough of the material for immediate distribution should be prepared, as it deteriorates when kept for several days. It is best



FIG. 5.—Men distributing poison.

distributed by hand (fig. 5), placing a small pinch, equal to a teaspoonful, near the entrance of each burrow, and scattering a little here and there along the surface trails. Care should be taken to place the poison a little to one side of the mound (fig. 6) to prevent it from being covered by the earth thrown out. In cold weather, when the mice move about chiefly in their underground runs, it should be dropped *into the burrows*. The dampening of the hay freshens it remarkably and makes it a tempting substitute for green food. Many of the animals eating it die on the surface, but about 60 per cent of those destroyed die underground. The poison is effective for several days, and since much of it is carried into the burrows to be eaten later, its full effect is not at once evident.



FIG. 6.—Where to place the poison.

Some farmers hesitate to distribute poisoned hay over their land for fear of poisoning stock. If properly done, however, there is practically no danger. The proportion of strychnine is small and cal-

culated especially for mice. Rain or the irrigation of fields renders harmless any of the material left, and the small quantity it is necessary to put out soon shrivels to almost nothing from exposure to the sun. In Humboldt Valley extensive poisoning was not attended by a single accident. It is recommended, however, that stock be kept out of fields for a few days after poison has been distributed.

Green alfalfa.—In Carson Valley, in April, poisoning with green alfalfa hay was strikingly successful. Although the experiments in alfalfa fields were in places where green food was abundant, still nearly all the mice were killed in the areas treated (fig. 7). These



FIG. 7.—Field mice poisoned by green alfalfa.

animals habitually cut and store sections of alfalfa shoots during summer, and it is not surprising that the same material poisoned and placed in their runs should prove effective.

Formula.

Green alfalfa.....	45 pounds.
Strychnia sulphate.....	1 ounce.
Water.....	1½ gallons.

Procure fresh green alfalfa, preferably young shoots, though leaves and tops of older plants also are good. Chop into lengths of 2 or 3 inches and place in a water-tight receptacle. Heat the strychnia in half a gallon of water in a closed vessel until thoroughly dissolved. Add the poisoned solution to one gallon of cold water and sprinkle it

slowly over the alfalfa, mixing until the moisture is all taken up. In general the same method of distribution recommended for alfalfa hay should be followed. Several short pieces are sufficient for each burrow. Owing to the abundance of green food, greater care should be exercised in placing baits in the holes and along runways. As green alfalfa withers quickly when exposed to the sun, evening hours or cloudy days are best for its distribution. Though it can hardly be used extensively enough to suppress well-established plagues, it is recommended for small areas, or where mice are not excessively numerous. It is especially valuable for destroying mice along ditch banks or about the borders of fields during the irrigation of fields in summer.

Crushed wheat.—Crushed wheat possesses decided advantages over whole grain as a medium for poison. It is easier to prepare, and is more readily eaten, especially by young mice in summer. While considerably more costly than the phosphorus preparation, it is much less objectionable. The cost is not serious when mice are not extremely abundant over large areas, or when it is used to prevent plagues in the earlier stages.

Formula.

Crushed wheat.....	60 pounds.
Strychnia sulphate.....	1 ounce.
Water.....	2 gallons.

Heat the strychnia sulphate in the water in a closed vessel until completely dissolved. Sprinkle the solution over the wheat and mix well. Sweetening or scenting the preparation is unnecessary and even detrimental. When it is desirable to keep the poison several days, add two tablespoonfuls of powdered borax to prevent fermentation.

This preparation was used extensively in Carson Valley in April to check a plague of mice before alfalfa became too high to prevent effective poisoning. About 85 per cent of the mice were killed by a single treatment, and this was followed later by poisoning along the ditches and in other places where the animals persisted. The cost was about 40 cents per acre.

During these operations many blackbirds and magpies were poisoned. To a less extent meadow larks, killdeer, and mourning doves were destroyed. Though in this instance poisoned grain could not be replaced by less destructive preparations, it should, when possible, give place to poisoned green alfalfa. Winter poisoning with alfalfa hay will usually prevent the necessity for summer poisoning.

OBLITERATING BURROWS.

In the lands traversed by the scourge in Humboldt Valley, where over large areas mouse holes were scarcely a step apart, it was at once evident that there was great waste of material and labor in

poisoning. Usually there were ten or more holes for each pair of mice, and in fields partially deserted the proportion of unoccupied holes was much greater. When all the holes were obliterated, the mice soon reopened those occupied, and poisoning could be done with



FIG. 8.—Brush drag used to obliterate mouse holes.

the certainty of treating only the occupied burrows. A brush drag (fig. 8) proved best for the purpose. By this method a saving of about 40 per cent in labor and material resulted, and the average cost of destroying mice with alfalfa hay was reduced to about 35 cents



FIG. 9.—Effect of brush drag, showing mouse holes in part not dragged.

per acre. While obliterating holes is practicable only under such extreme conditions as were presented in Humboldt Valley (fig. 9), it there proved of the greatest importance.

IRRIGATION.

Though irrigating in summer destroys a large percentage of the very young mice, it does not considerably reduce the number of adults. Moving ahead of the flood, they dart in and out of holes

already full of water, swimming considerable distances through their underground tunnels. They cross ditches and furrows readily, traveling by water almost as easily as by land. Many take refuge in elevated spots and in straw or other litter in the fields, but by far the greater number are driven to the elevated ditch embankments and to the borders of fields. Within a few days after the water is withdrawn they again abound in the fields. Irrigation affords many opportunities for destroying the mice, both by poisoning and by dogs. It has also the effect of obliterating the burrows, so that for the next few days poisoning can be practiced with greater saving, since the occupied burrows are easily recognizable.

WINTER FLOODING.

It is said that flooding the fields in cold winter weather is an effective method of destroying mice, as when forced out of their burrows they soon perish from exposure, or are easily killed by dogs. This method has been successfully practiced in Carson Valley, and appears to be well worth trial. It can not be practiced in all irrigated districts, however, on account of the shortage of water at this season. It should be accompanied by poisoning along the ditch embankments and about the borders of fields.

BURNING.

In and about cultivated fields are many little areas where mice breed undisturbed. Waste strips along streams, swampy areas, and, on a larger scale, natural hay lands, serve as breeding places from which cultivated fields are invaded. Poisoning is not usually practicable in such places. Burning off the rank grass and weeds in winter or early spring is a great help in controlling field mice. Many of them perish, and the land is made uninhabitable for the survivors, driving them to locations where they may be more readily destroyed. In concerted attempts to control field mice, burning such areas should always precede poisoning operations.

DESTRUCTION OF WINTER COVER.

Very important in any attempt to control field mice is the keeping down of rank grass and other cover along ditches and about the borders of fields. The grass in such places is frequently left in haying time, because of the difficulty in cutting it. The last growth of alfalfa is often left to be killed by frost, when it should be pastured off or otherwise disposed of. Such cover affords the mice excellent protection from hawks, owls, and other predaceous birds.

PROTECTION OF TREES.

Clean cultivation is the greatest safeguard to trees. Where rank grass, weeds, or cover crops are allowed to remain under the trees in winter, the attack of field mice is invited. Damage to orchards is usually done under cover of weeds and snow and may reach serious proportions before being noticed. Many trees may be so badly injured that recovery is impossible, but most of them can usually be saved by promptly banking up earth about the trunks, entirely covering the wounded parts.

For protecting young trees thin wooden wrappers, called "tree protectors," are valuable. It is also highly probable that the lime and sulphur wash used by entomologists would prove effective. It should be applied at the beginning of winter.

DOGS AS MOUSE DESTROYERS.

Dogs are worth many times their keep when trained to hunt mice. Fox terriers or other small breeds take readily to hunting them and during irrigation and plowing destroy great numbers. Many farmers in Nevada keep dogs for the purpose of killing ground squirrels, pocket gophers, and field mice as they are forced out of their burrows by water, and in this way keep the pests in check. Plows turn out of the burrows practically all the field mice present, so that they become easy victims for dogs. Dogs trained to follow plows very materially reduce the number of mice in the areas covered. As an inexpensive and effective help in controlling field mice, dogs can not be too highly recommended.

SUMMARY OF REPRESSIVE MEASURES.

It has been proved that field mice are easily controlled by poisoning, or by a combination of poisoning and other methods, so there is little excuse for permitting mouse plagues to develop. Constant attention is obviously the way to avert such scourges. The encouragement of natural enemies, the destruction of rank cover, the keeping of well-trained dogs, and a little poisoning in winter, are ordinarily sufficient to hold the pests in check.

On account of its extremely dangerous character and the widespread destruction it causes, the use of phosphorus is not advised, especially since strychnia sulphate is fully as destructive to the mice at no greater cost. When mice are abundant in winter and early spring, thorough treatment with poisoned alfalfa hay will usually prevent serious damage in summer. When from neglect of this, or through other cause, it is necessary to destroy mice in summer, poisoned green alfalfa will commonly suffice. To avert threatened plagues

at this season, where it is necessary to treat large areas quickly, poisoned crushed wheat is the best agent to employ.

NATURAL ENEMIES OF FIELD MICE.

Of the many remarkable features of the mouse plague in Humboldt Valley, none is of greater interest, or indeed, of greater significance, than the large numbers of birds and mammals which gathered to feed on the mice. In all other localities menaced these valuable allies of the farmer appeared in similar abundance. Under rows of trees, about the bases of fence posts, and scattered everywhere in the fields were regurgitated pellets of mouse fur and bones, affording abundant proof of the services rendered by birds; while many holes and destroyed nests in the fields showed the work done by skunks and coyotes. So apparent was the assistance rendered by these creatures that it attracted the attention and secured the protection of the farmers, many even sparing the coyote, whose services as a mouse destroyer deserve to be more widely recognized. In Nevada coyotes were frequently seen catching mice in the daytime, and their droppings were composed entirely of mouse fur and bones.

It is deplorable that, even when their usefulness is as apparent as here, some persons continue to destroy valuable birds and mammals. During the investigations in Humboldt Valley, no less than 29 large hawks were found hanging on wire fences, their useful lives ended by thoughtless gunners.

The striking evidence of the valuable services of the natural enemies of mice seen during this plague is but an example of their constant value. Hawks, owls, gulls, crows, ravens, herons, and shrikes among birds; and skunks, coyotes, foxes, weasels, badgers, and wildcats among mammals habitually prey upon field mice, and are most valuable in preventing undue increase of these pests.

Thorough studies have shown hawks and owls to be most beneficial allies of the farmer, orchardist, and nurseryman.^a Most species rarely, and many of them never, attack poultry. But even were the depredations of the several species which kill poultry much more considerable, a small price would be paid for their services in destroying rodents. In the Nevada valleys all species of hawks and owls are distinctly beneficial, and here rigorous protection can not be too strongly advocated.

Among mammals the weasel and the skunk are especially worthy of protection. They are most persistent enemies of mice, and are less likely to be driven out by civilization than are other mammals. When

^a See Circular No. 61 of the Biological Survey, Hawks and Owls from the Standpoint of the Farmer.

particular individuals raid poultry houses it may be necessary to destroy them, though usually it is easy to make such houses proof against their attacks. Far from being a menace, they are generally most beneficial mammals, and living, are worth many times the value of their pelts.

It is gratifying to note that in many localities the people are learning to appreciate these natural enemies of rodent pests, for even more important than legislation for the protection of valuable birds and animals is the recognition of their services by the farmers.

In Nevada it was noticed that hawks and owls hunted chiefly in fields near the few plantations of large trees to be found in the valleys. Beneath these trees the ground was fairly carpeted by disgorged pellets of fur and bones, representing thousands of mice. While certain species of hawks seldom frequent trees, others habitually perch in them, notably the large rough-leg, Swainson, and red-tail, which were the most abundant and persistent mousers. In nearly all of the valleys, even those which have been farmed for years, the absence of trees is notable. More trees along ditches, about the borders of fields, and in groves here and there would doubtless increase the number of valuable resident hawks and owls and attract more winter visitors.

CONCLUSIONS.

The plague of field mice in Nevada illustrates the dangerous peculiarities of this group of rodents and stamps them as most serious pests. Since field mice possess in marked degree the tendency to periodic excessive multiplication, plagues are possible wherever they exist. In view of the natural increase of field mice resulting from the reclamation of desert lands and the gradual extirpation of their natural enemies, mouse plagues of vastly greater proportions are by no means improbable.

An understanding of the manner in which such plagues develop is essential in attempts to prevent them. Control, easy in the beginning, becomes very difficult and expensive after a plague is well established. In Humboldt Valley, in the beginning, a little poisoning with green alfalfa or crushed wheat would have sufficed to prevent the plague. During the fall and winter of 1906-7, when the mice seriously injured fields here and there, they could have been destroyed with poisoned alfalfa hay. Even during the summer of 1907 concerted and vigorous poisoning would have destroyed them at a cost small indeed in comparison with the damage they inflicted later.

Winter poisoning with alfalfa hay is the most practicable, since the absence of green herbage is a distinct advantage. Ordinarily, poisoning in winter will prevent the necessity for it in summer. When, however, mice appear in alarming numbers in spring they should be

promptly suppressed, since under these conditions a plague may be well established by fall. But if in default of such preventive measures a plague is well established, nothing short of systematic and vigorous poisoning will check it. This requires the employment of enough men to cover the infested areas in a reasonably short time.

In localities where mice are present in destructive numbers, systematic effort to control them results not only in considerable saving to the ranchman, but proves the best safeguard against more serious damage.

On the enormous ranches of the West, the centers of abundance which form the starting points for general invasions may develop on the lands of persons who neglect to control them. If each ranchman will consider the suppression of field mice on his own land a regular part of farming operations, such scourges of mice will never occur.